The RISING project at GSI and its first results

Presented by Take R. Saitoh, GSI, Germany
for the RISING collaboration

Rare ISotope INvestigation at GSI

- **At relativistic energies (~100 A MeV)**

  July 2003 ~ April 2005

  - Coulomb excitation.
  - Secondary fragmentation and nucleon removal

- **With stopped beams**

  Fall 2005 ~ 2006

  - Decay study

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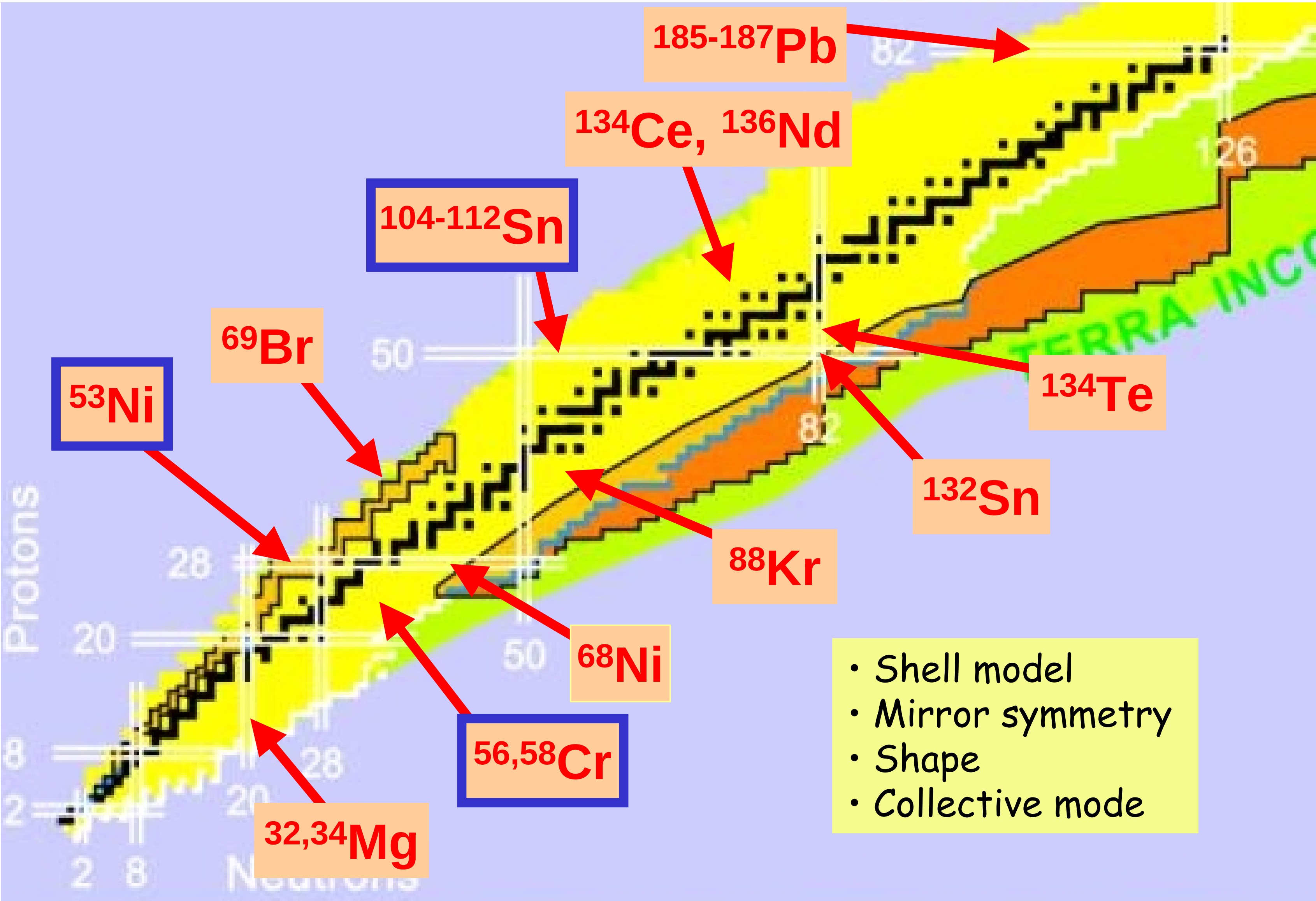
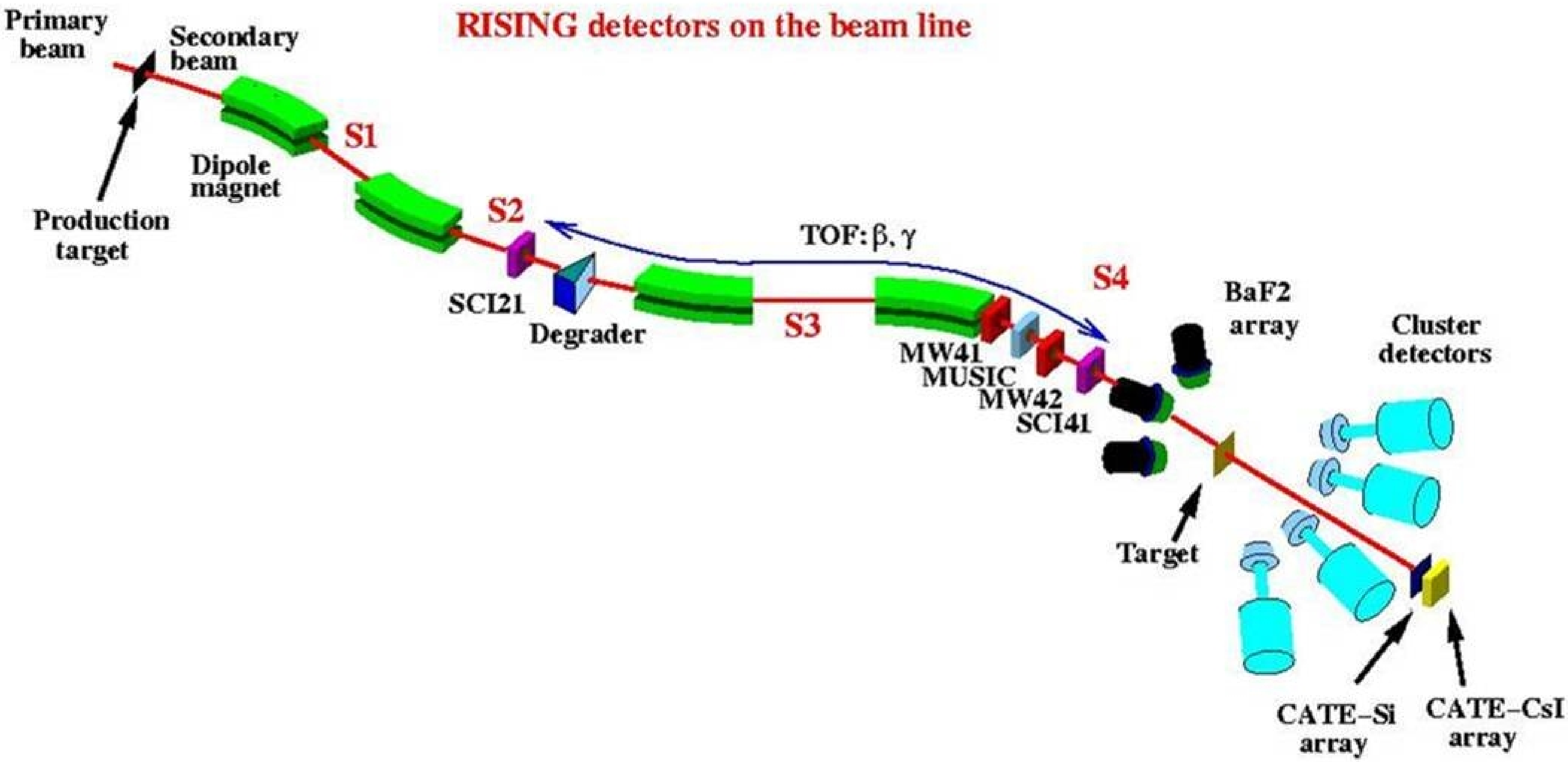
Physics program of RISING at relativistic energies – Nuclei of interest



- Shell model
- Mirror symmetry
- Shape
- Collective mode

Experimental setup



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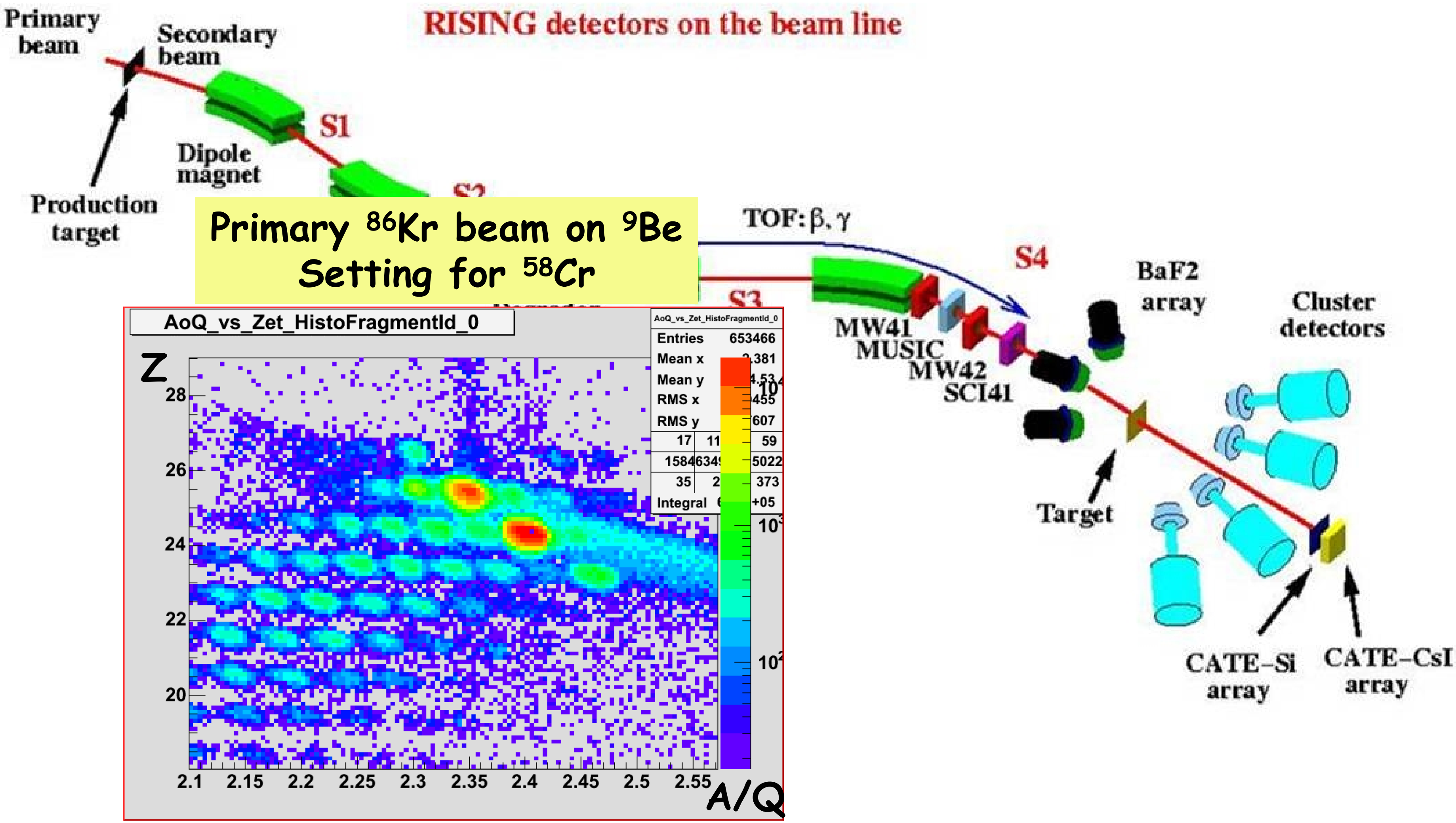

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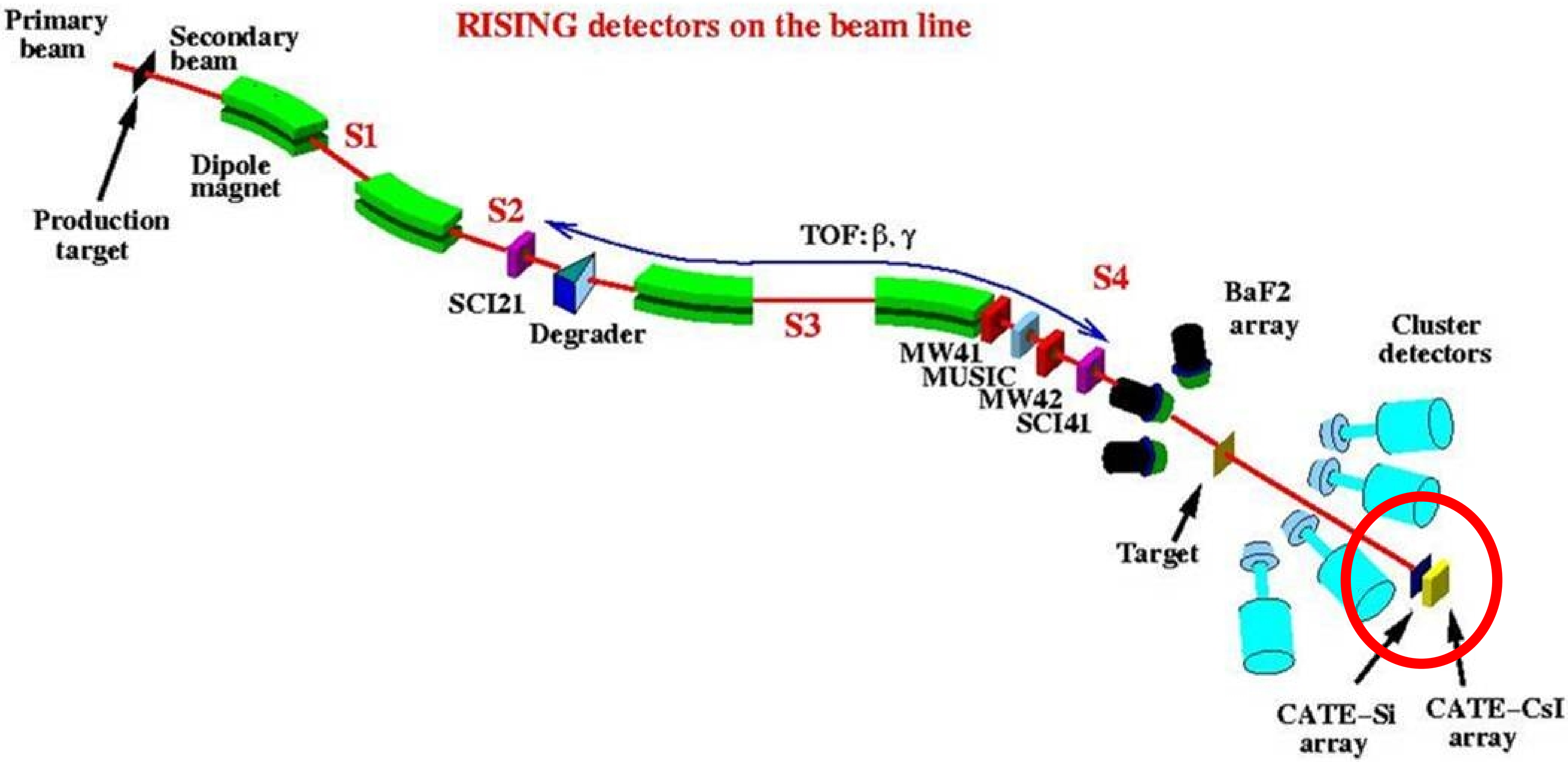

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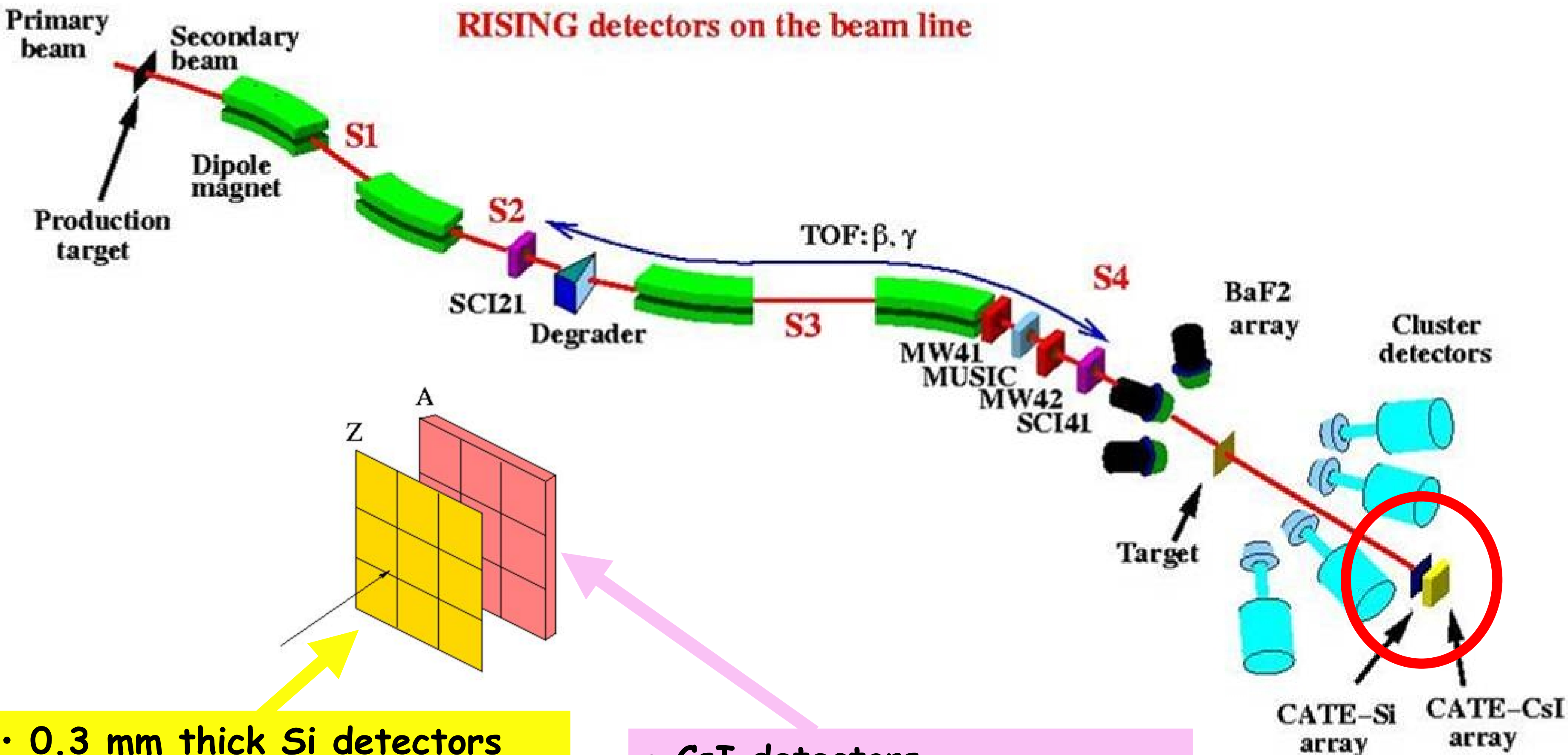
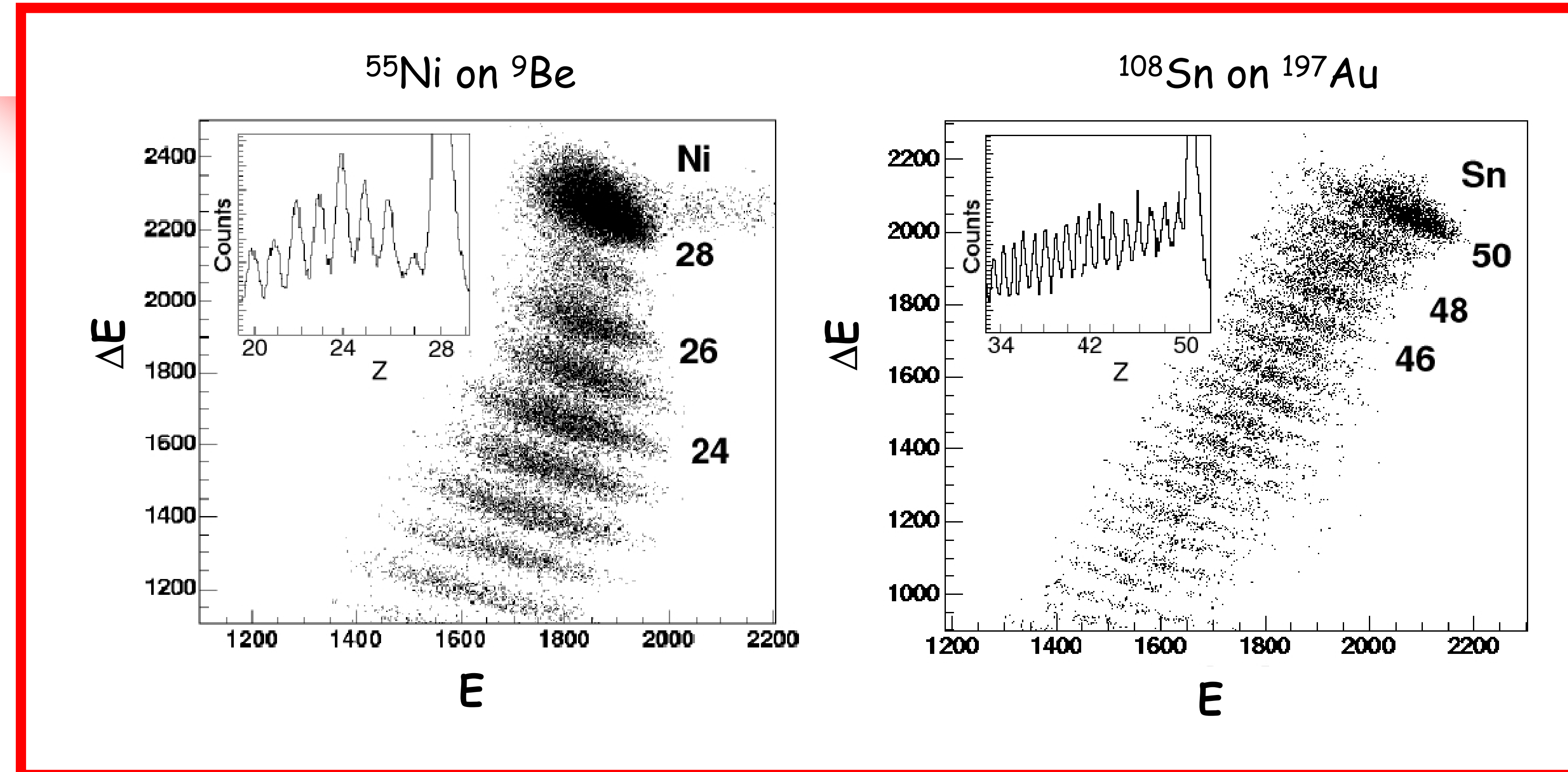
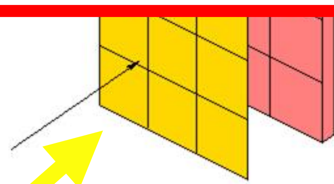


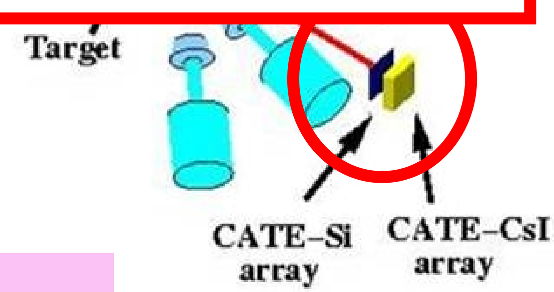
- 0.3 mm thick Si detectors
- Position sensitive. Position resolution ~3 mm

- CsI detectors
- Mass resolution : ~1%

R. Lozeva, Ph.D. thesis







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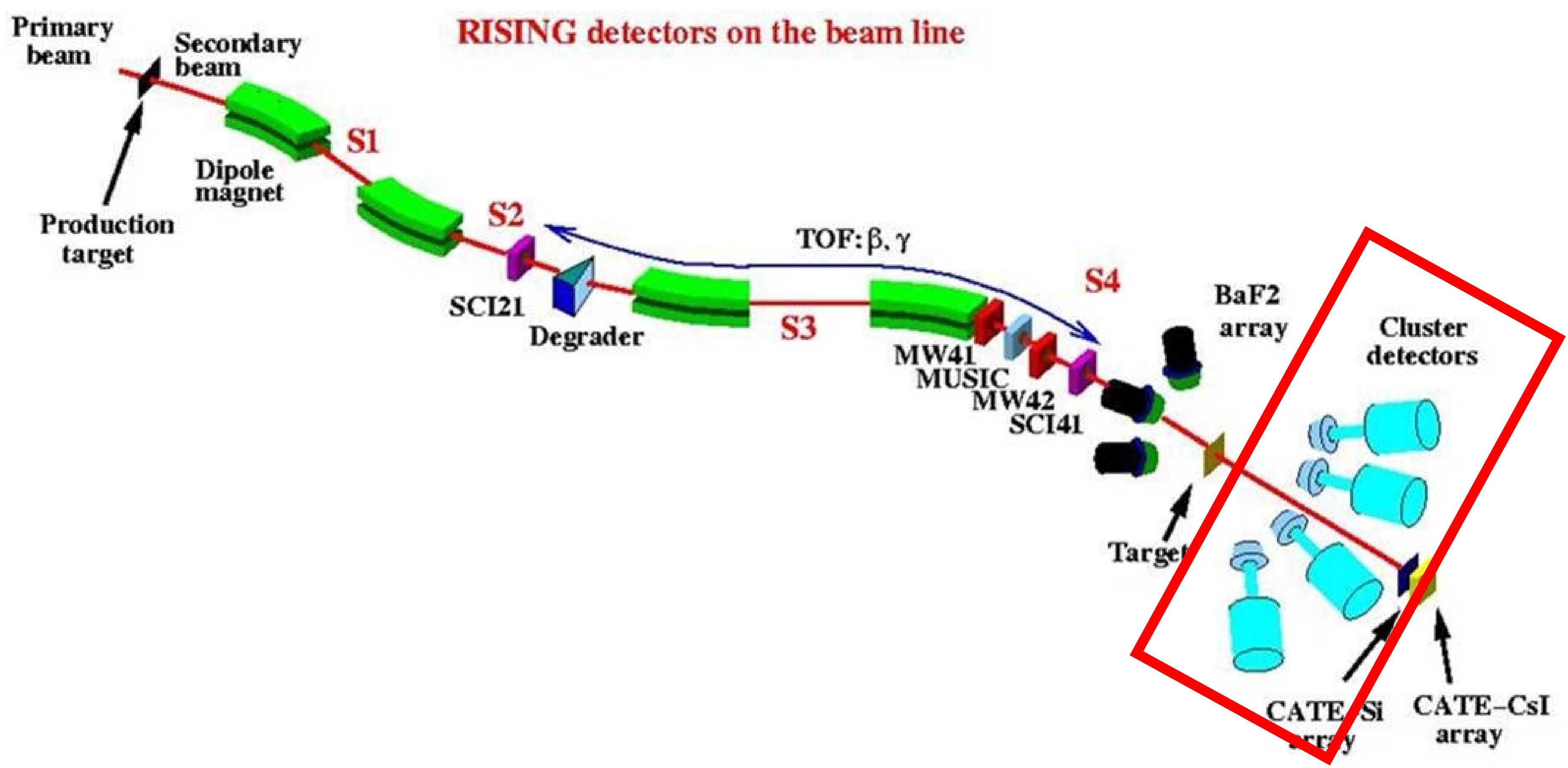
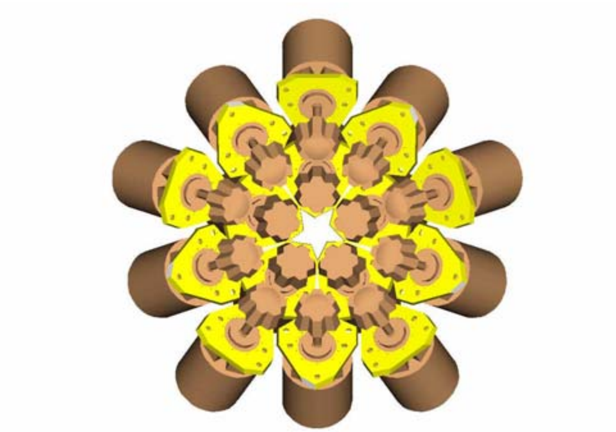
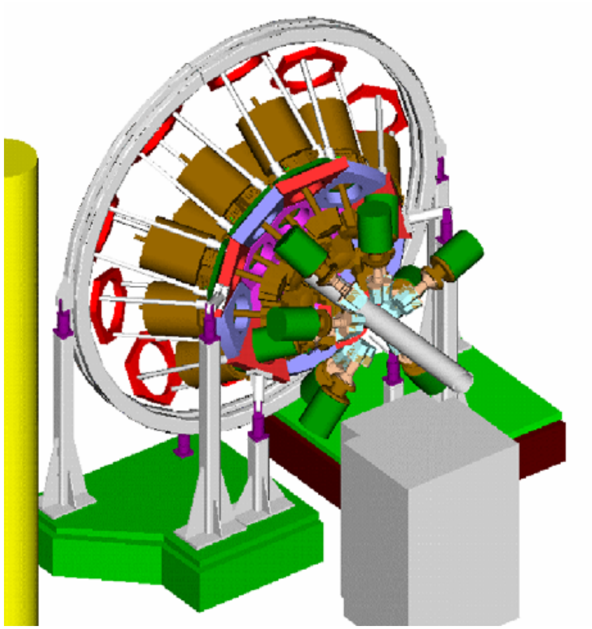


RISING at relativistic energies : Ge detector array





- **15 EUROBALL cluster detectors**
  - 7 crystals each
  - A total of 105 crystals
- **8 MINIBALL detectors (end of 2004)**
- **Wall-like array at forward angle**
  - **Large Lorentz boost (β~0.4)**
  - Optimum Doppler shift correction
  - Minimizing Doppler broadening

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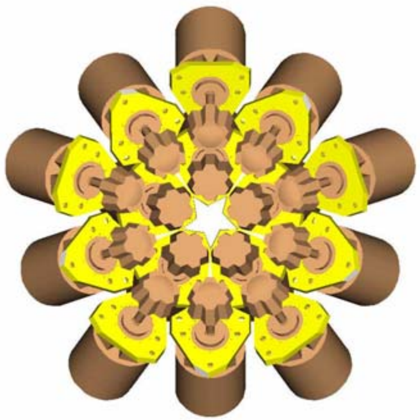

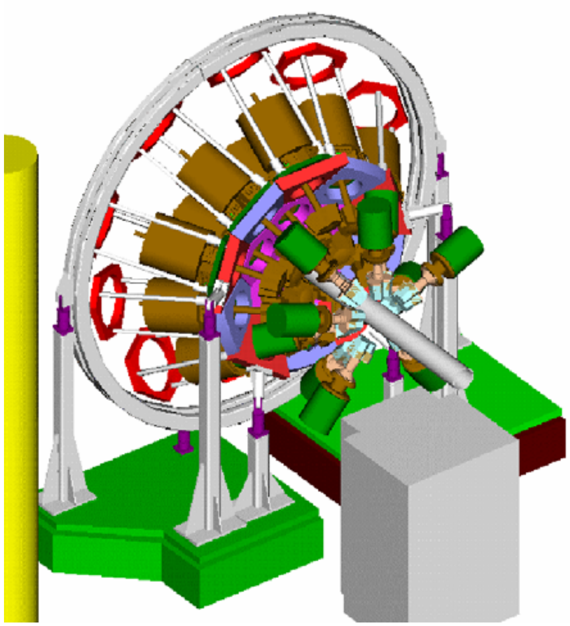

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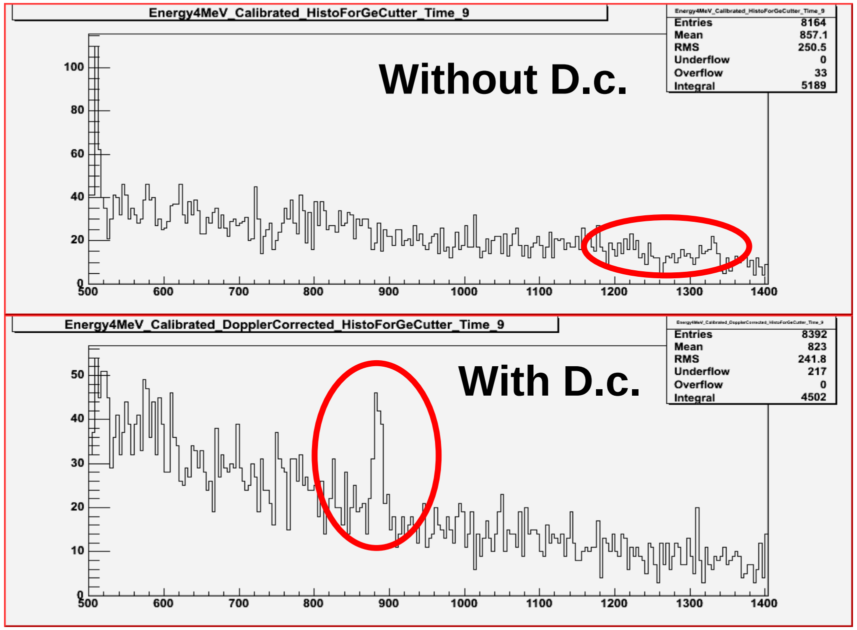
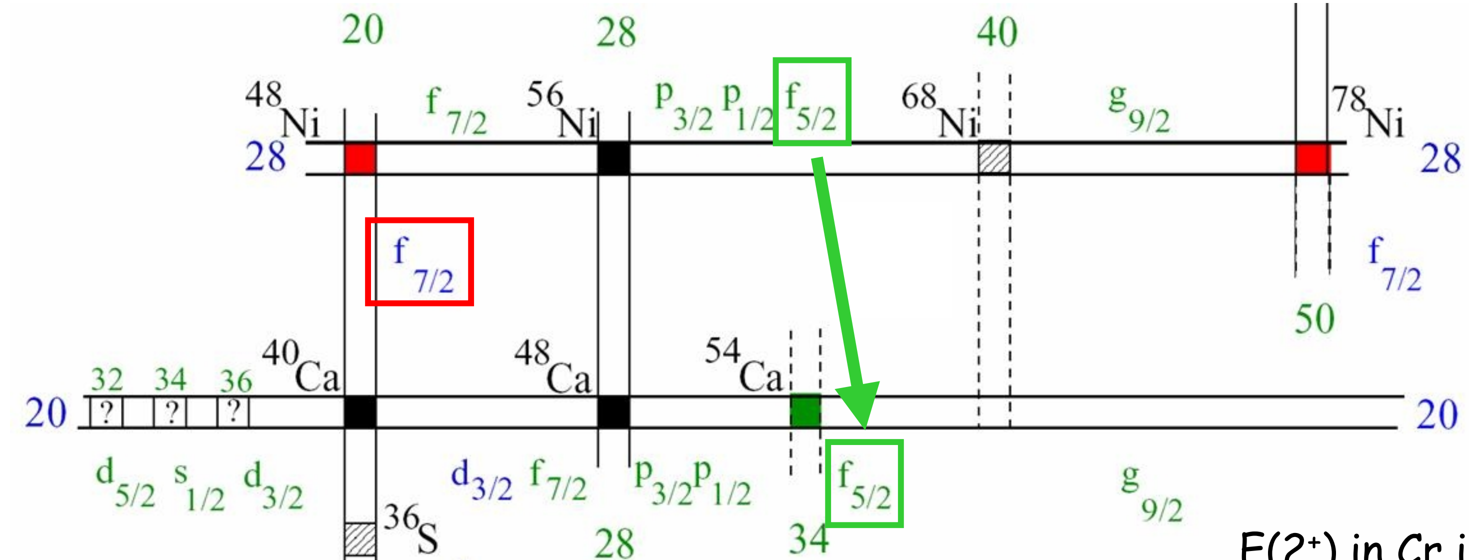
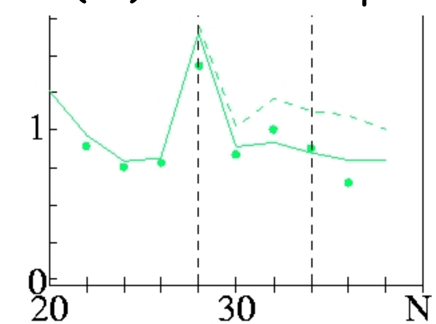


New Shell Structure at N>>Z
Relativistic Coulex in N=28-34, N=40-50 Nuclei



E(2+) in Cr isotopes



- Sub-shell closure at N=34 ?

- Local maximum of 2+ energy at N=32 in Cr isotopes

Coulomb excitation of ^{56}Cr (N=32) and ^{58}Cr (N=34): B(E2;2+->0+)
- Proposed by H.Grawe, P.Reiter, H.Hübel et al. Performed in May 2004

Coulomb excitation of ^{54}Cr, ^{56}Cr and ^{58}Cr

- Primary beam : ^{86}Kr at ~500 A MeV on the 4 g/cm^2 Be target
- Secondary beam : ^{54}Cr, ^{56}Cr and ^{58}Cr at 100 A MeV on the 1 g/cm^2 Au target

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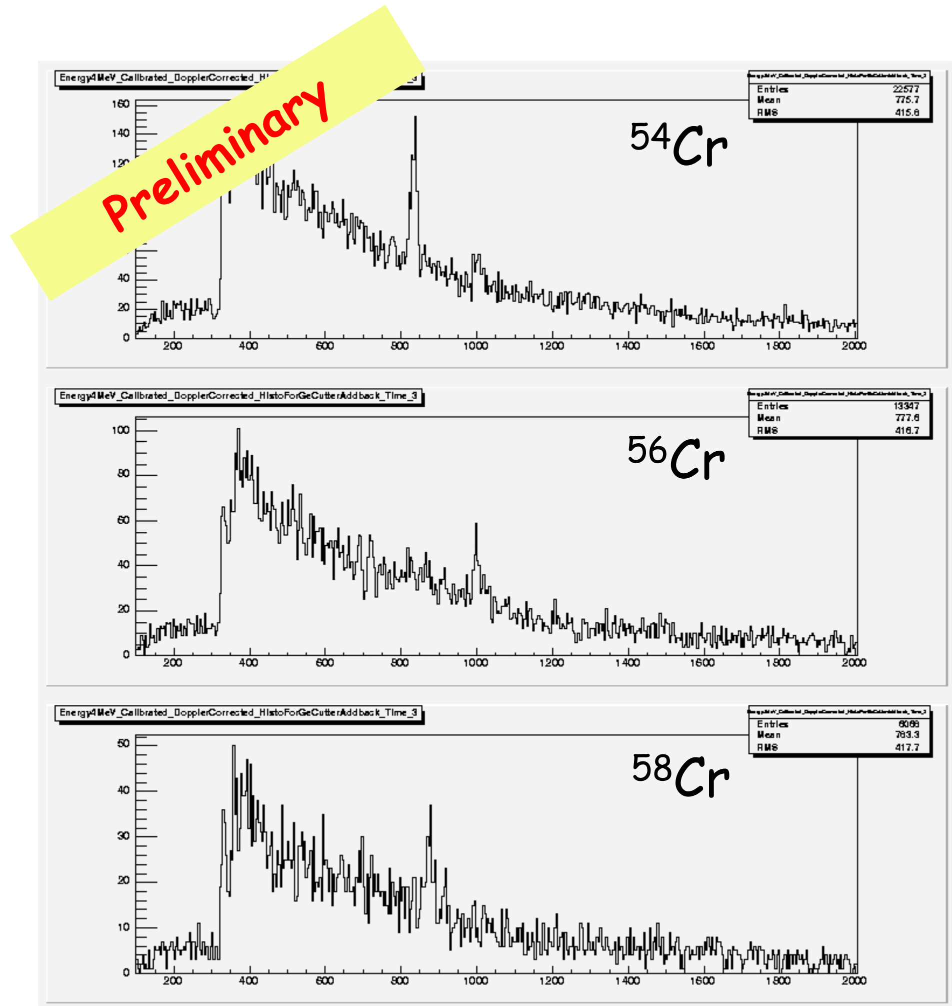

A. Bürger, Ph.D. thesis

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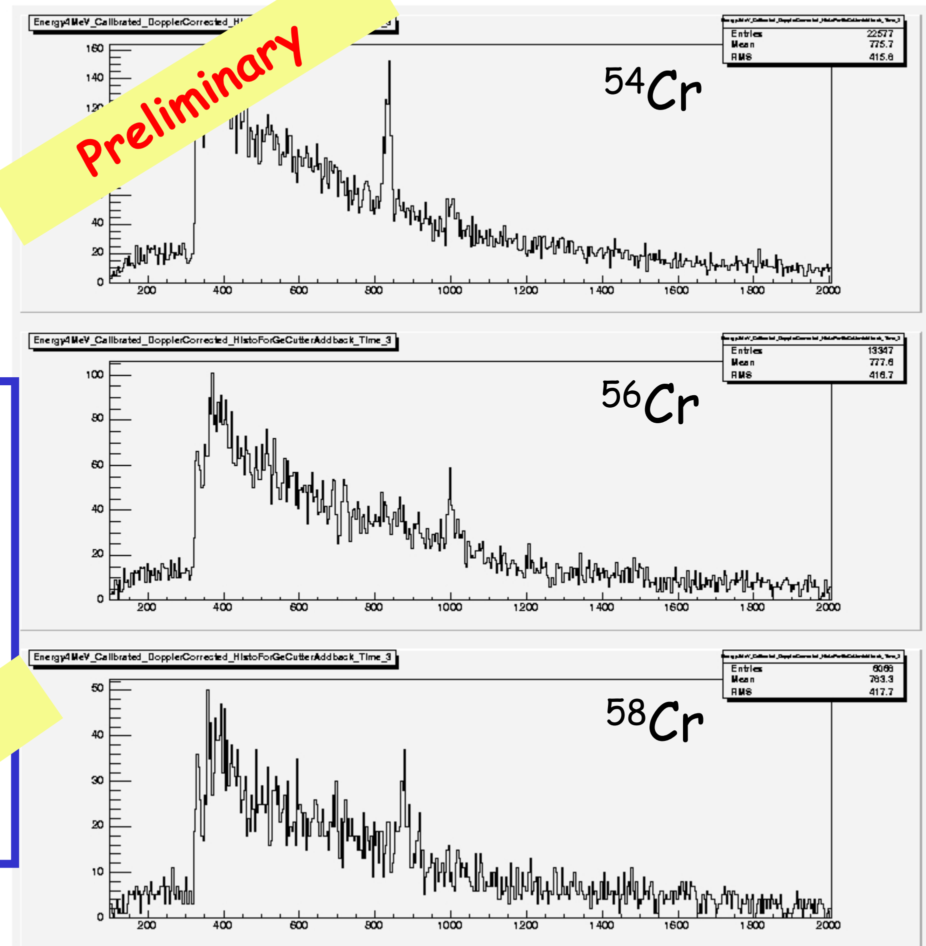


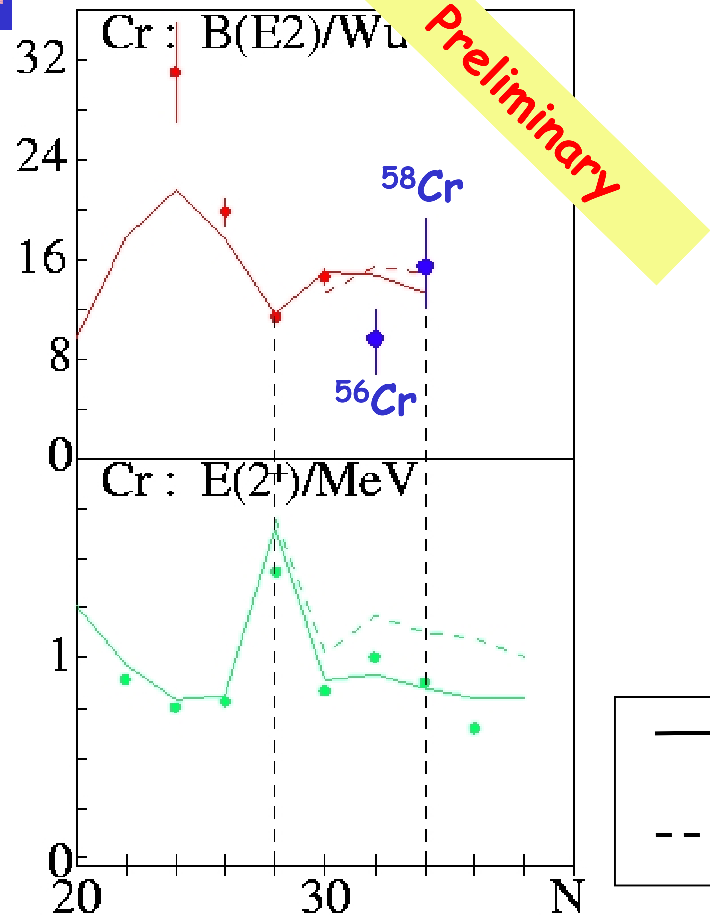
B(E2:2$^+$->0$^+$) values :

- ^{54}Cr : 14.6 ± 0.6 W.u.
  From NNDC, used as a normalization.
- **^{56}Cr : 9.7 ± 2.6 W.u.**
- **^{58}Cr : 16.1 ± 3.4 W.u.**

Preliminary

A. Bürger, Ph.D. thesis

B(E2:2⁺->0⁺) of ^{54}Cr, ^{56}Cr and ^{58}Cr



———	M.Honma et al, Phys. Rev. C65(2002)061301
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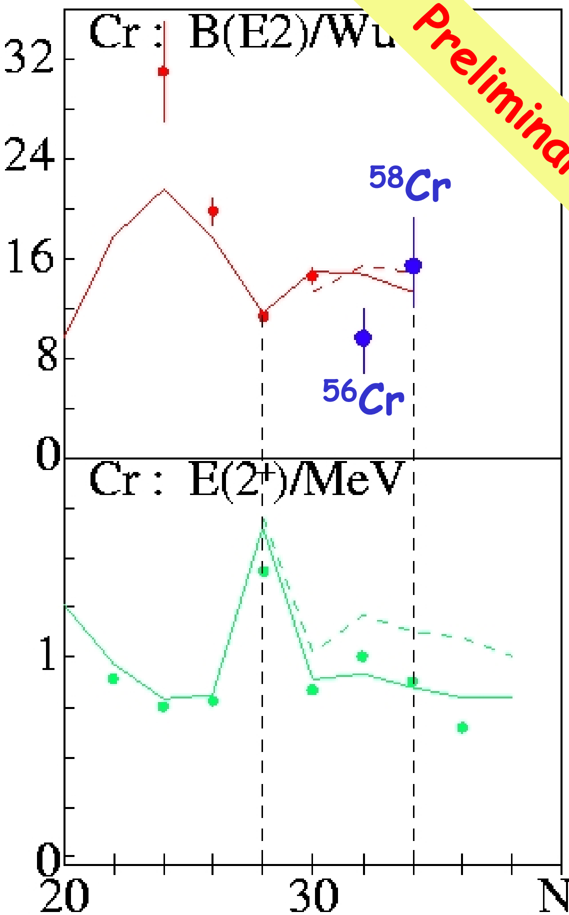

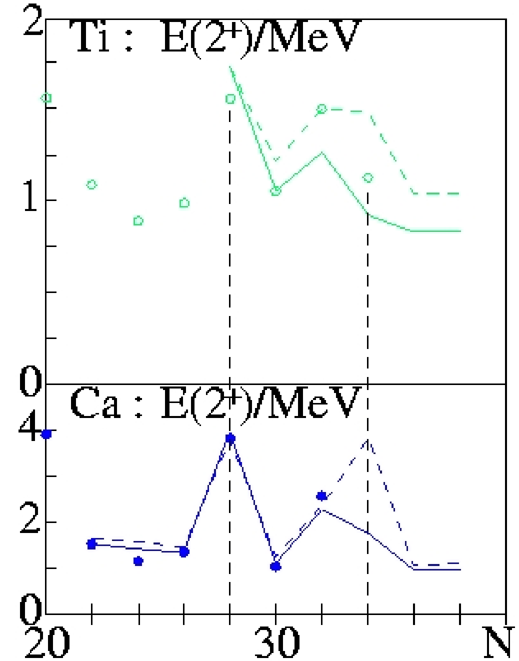

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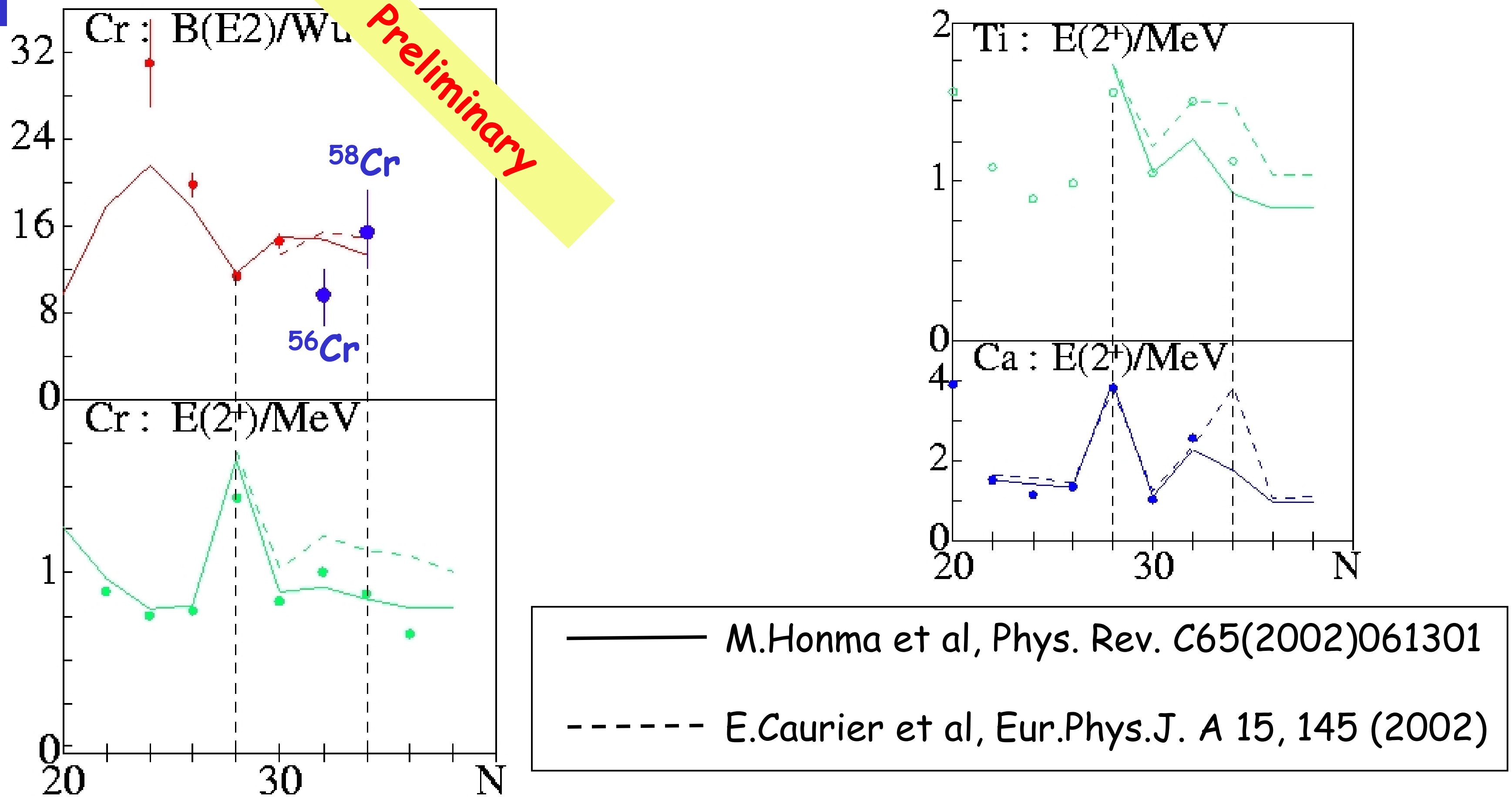


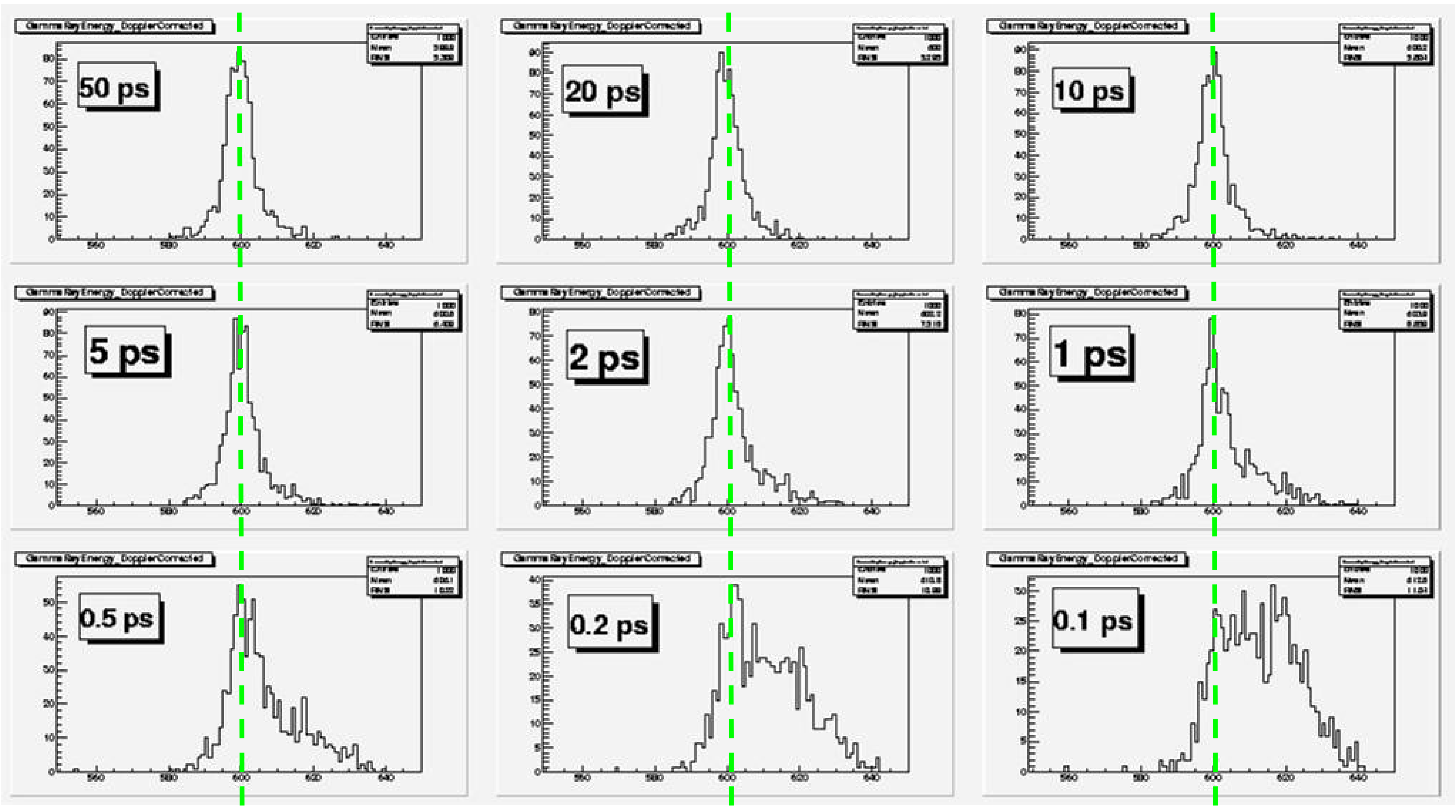
Indication of sub-shell closure at N=32 ?

→ Talk by A. Bürger in Zakopane, September

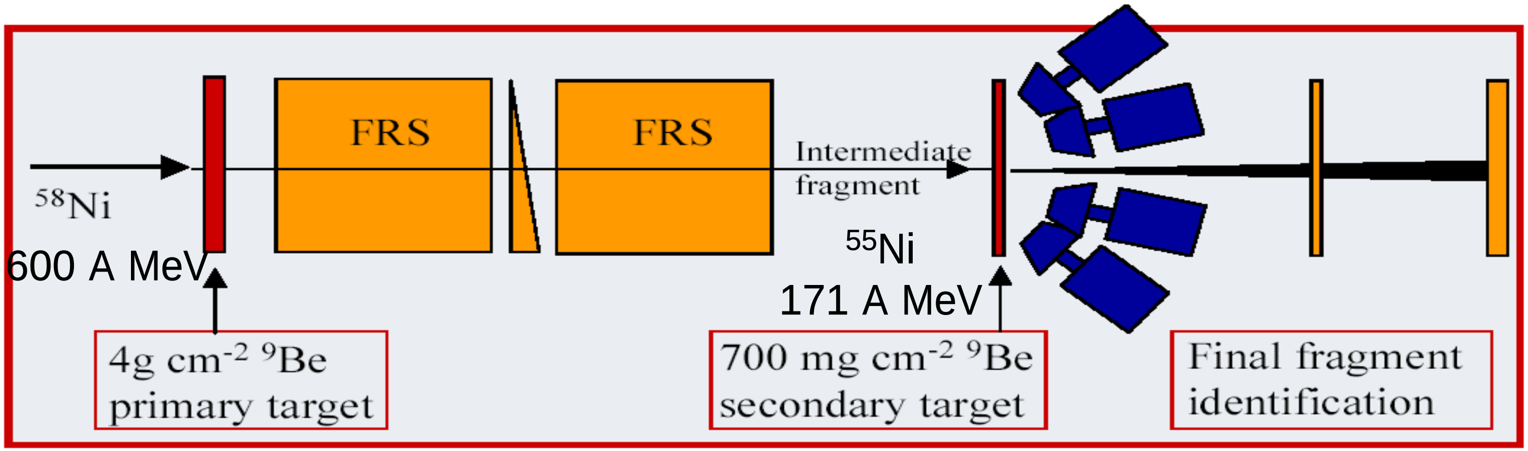
A. Bürger, Ph.D. thesis

Lifetime measurement by the line-shape analysis

Monte Carlo simulation.
^{132}Xe at 100 A MeV on the 0.3 g/cm^2 Au target



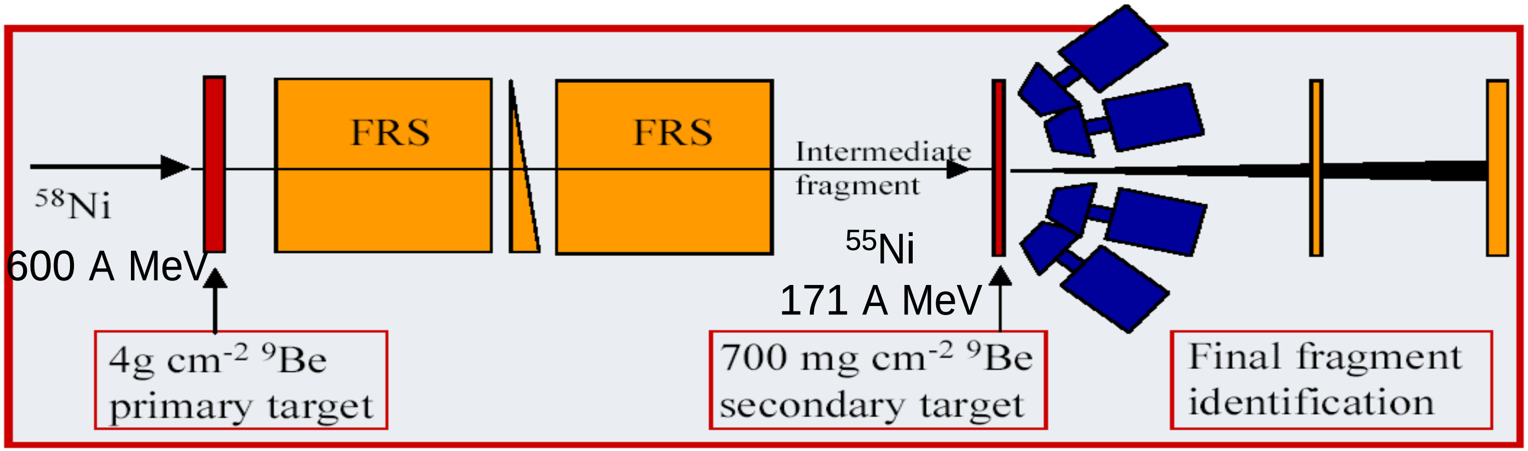
Mirror symmetry of ^{53}Ni and ^{53}Mn, investigation of the fragmentation process

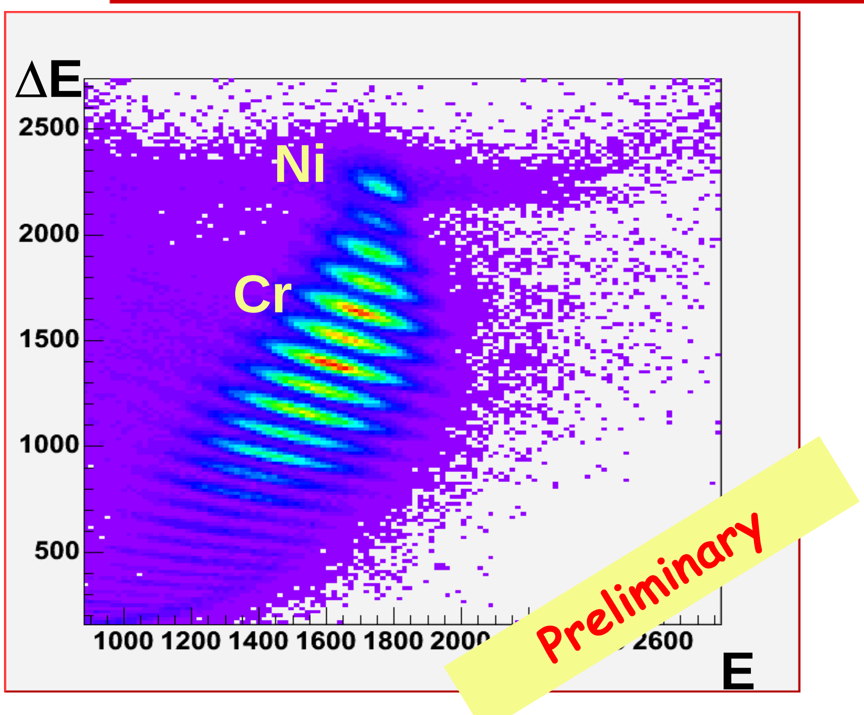


-> M.Bentley's talk

Ph.D. thesis, G.Hammond

Investigation of the fragmentation process





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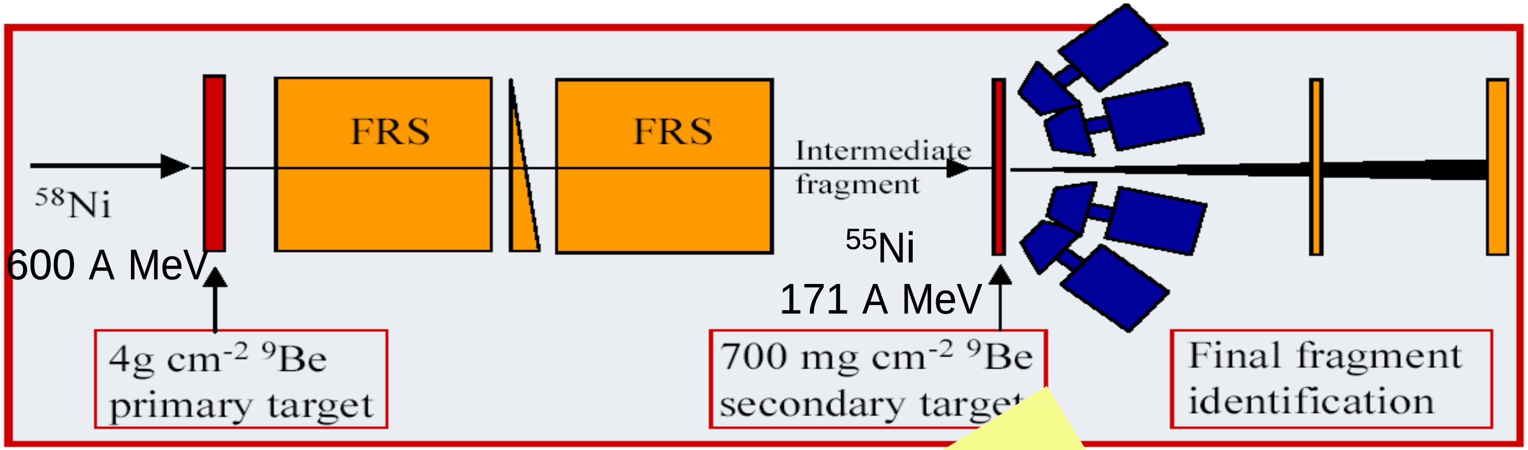
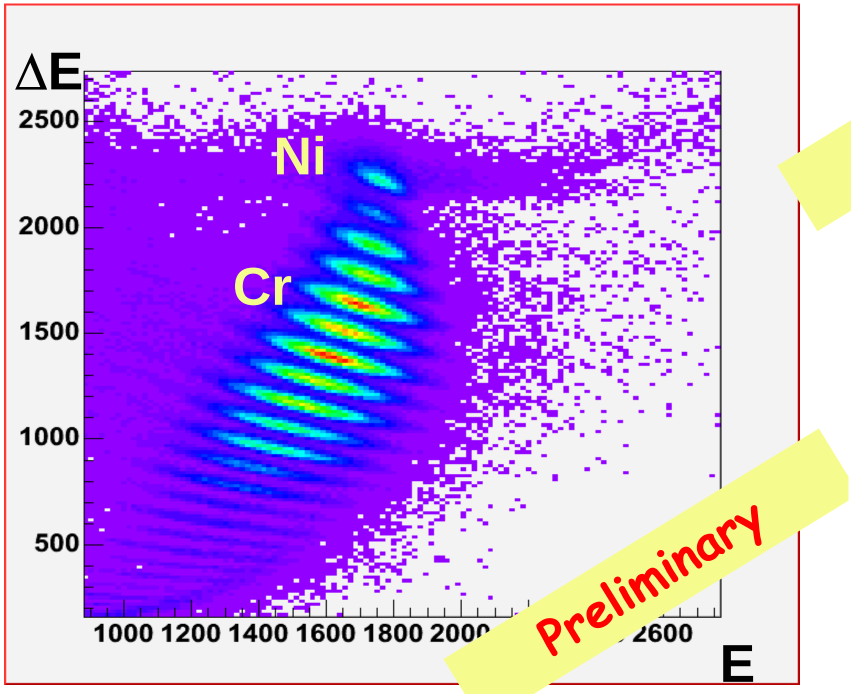
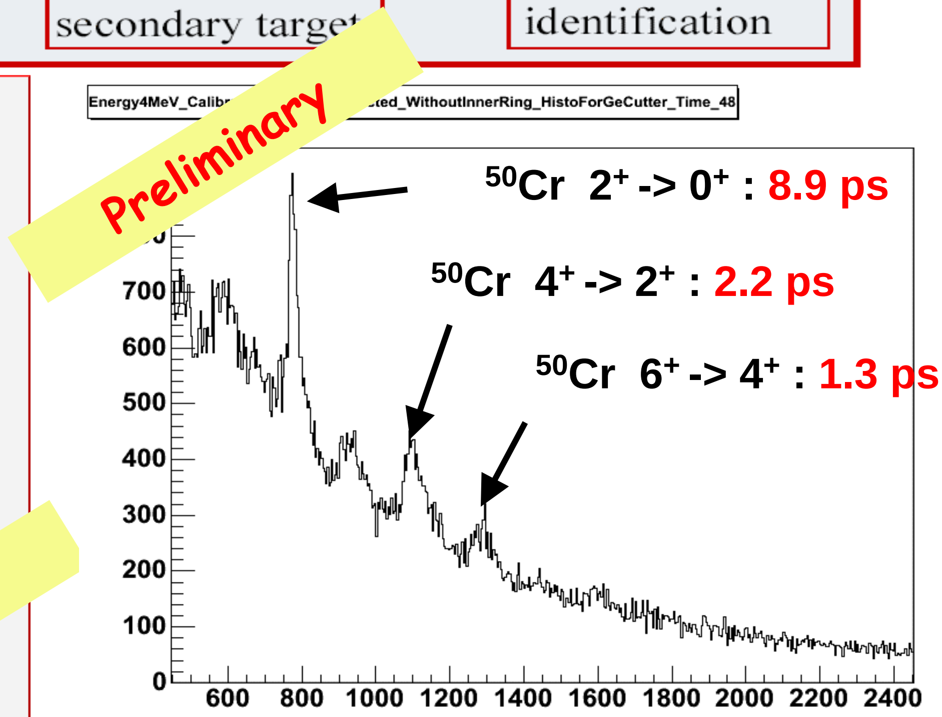


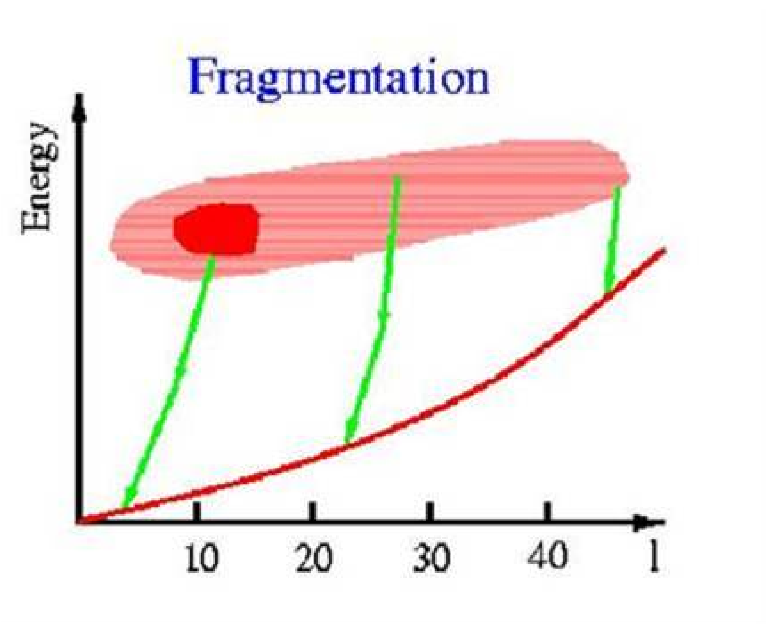


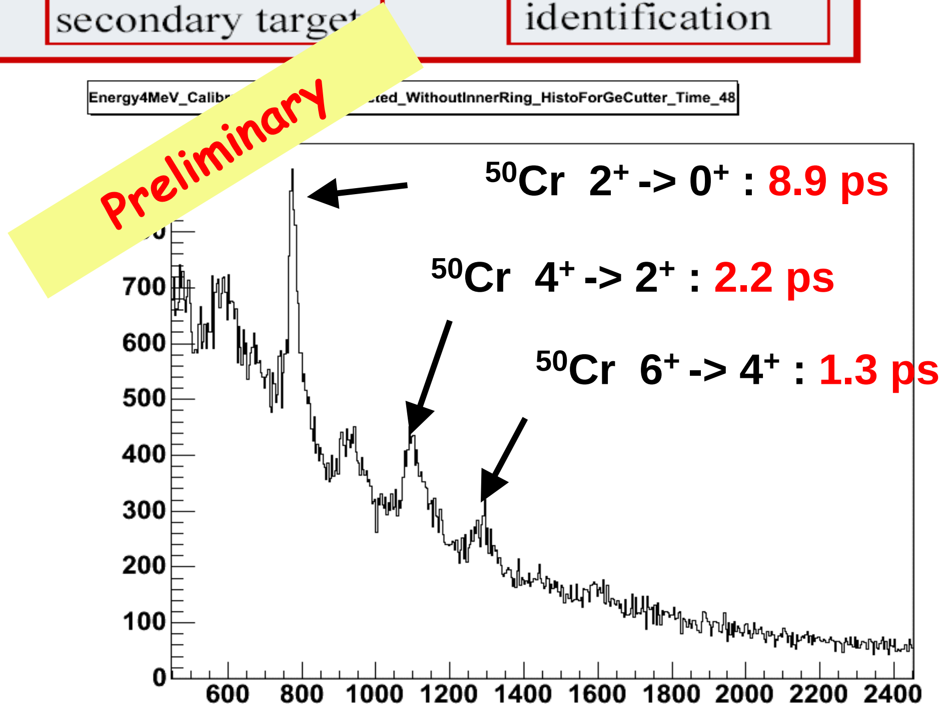


Investigation of the fragmentation process

- Expected longer effective lifetime for low-lying states
  - High excitation after fragmentation
  - Feeding to low-lying states

Apparent lifetime -> Excitation after fragmentation





Lifetime measurement with stacked target

- **Lifetime measurement of ^{32}Mg and ^{34}Mg with the secondary fragmentation method.**
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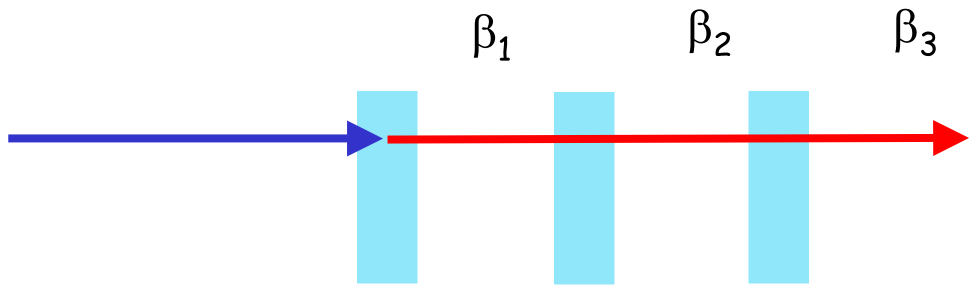

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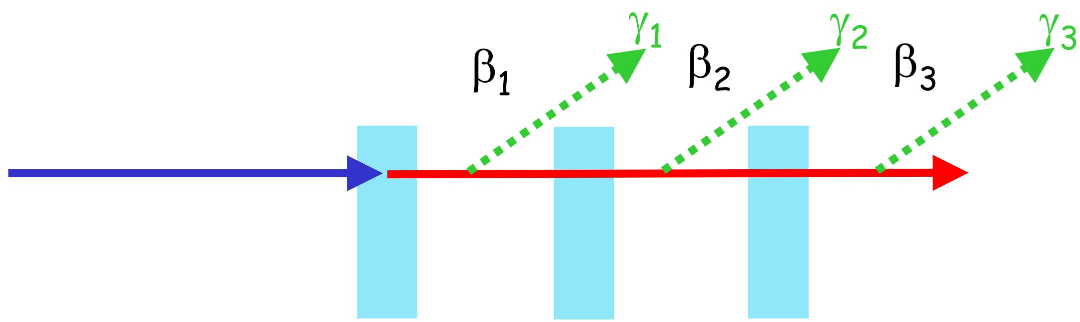

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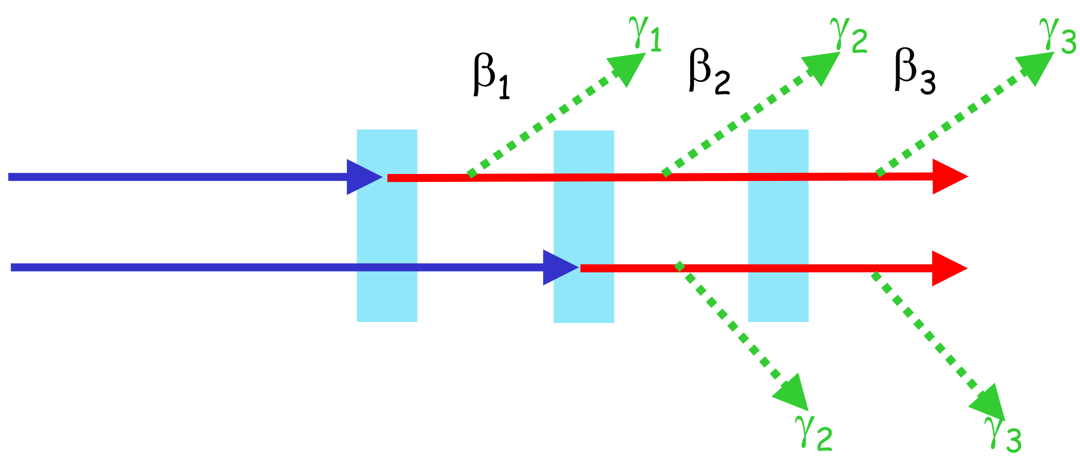

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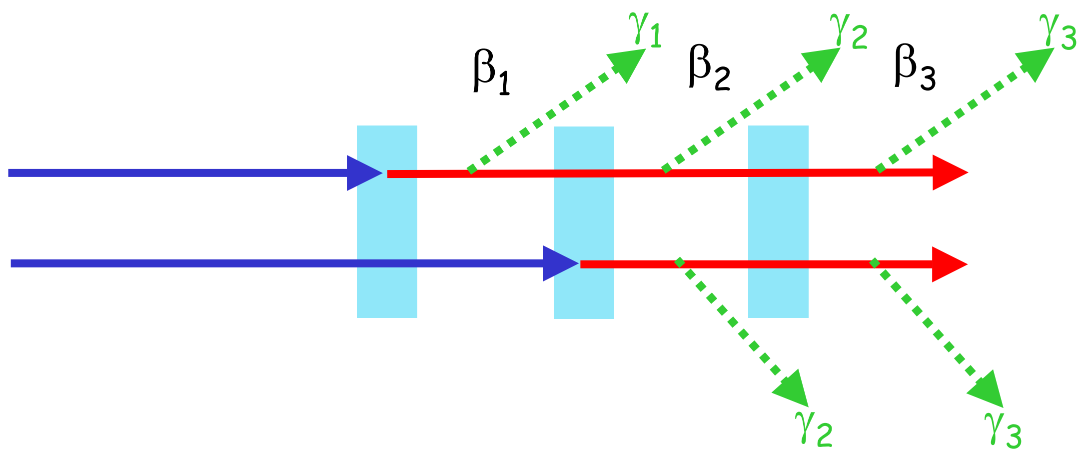
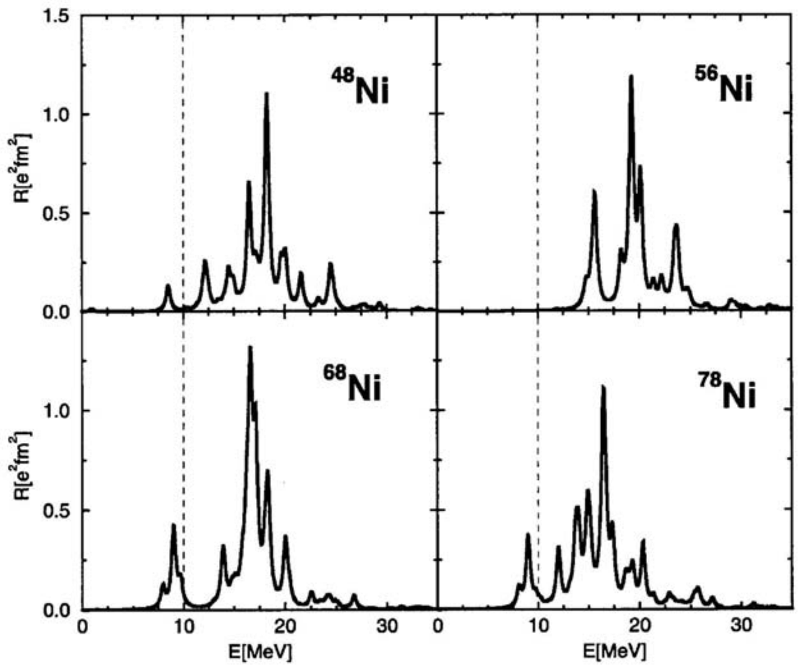


Intensity ratio, $\gamma_1 : \gamma_2 : \gamma_3$ -> Lifetime

GDR in exotic nuclei

- Giant Dipole Resonance (GDR).
  - Nuclear structure and effective NN interactions.
- Evolution of GDR strength toward light exotic nuclei.
  - Fine structures.
  - GDR at low energy.
- Proposed by A.Bracco et al for ^{68}Ni.



Relativistic RPA, Vretenar at al.

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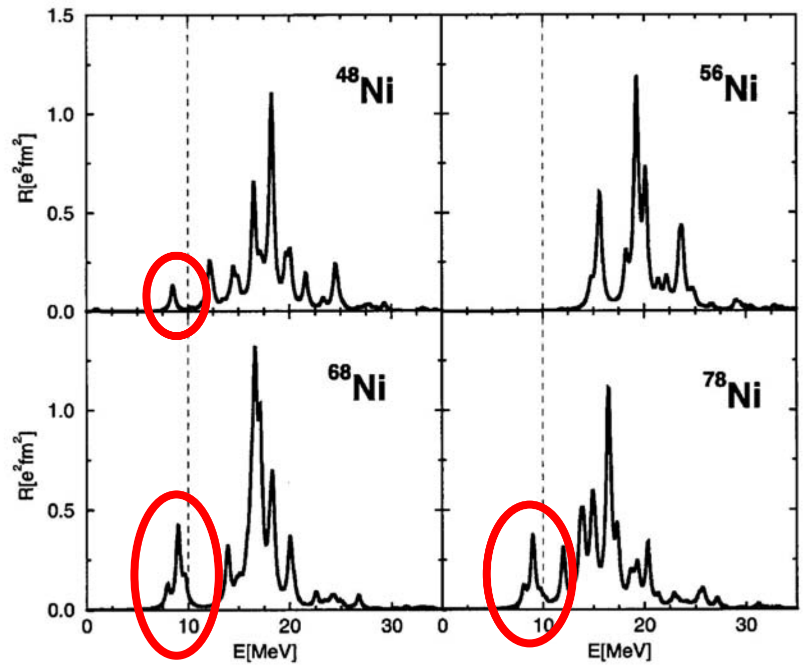

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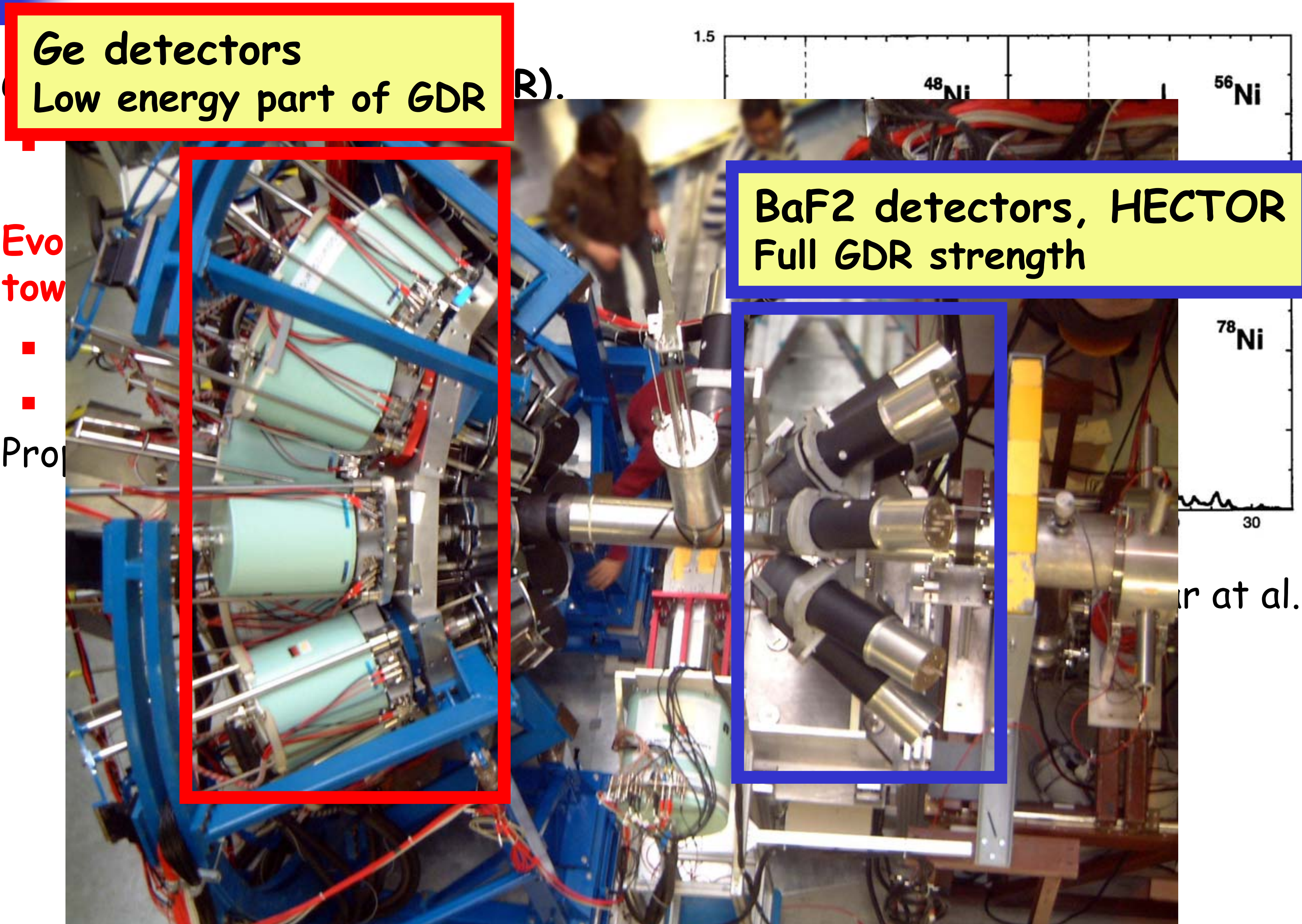
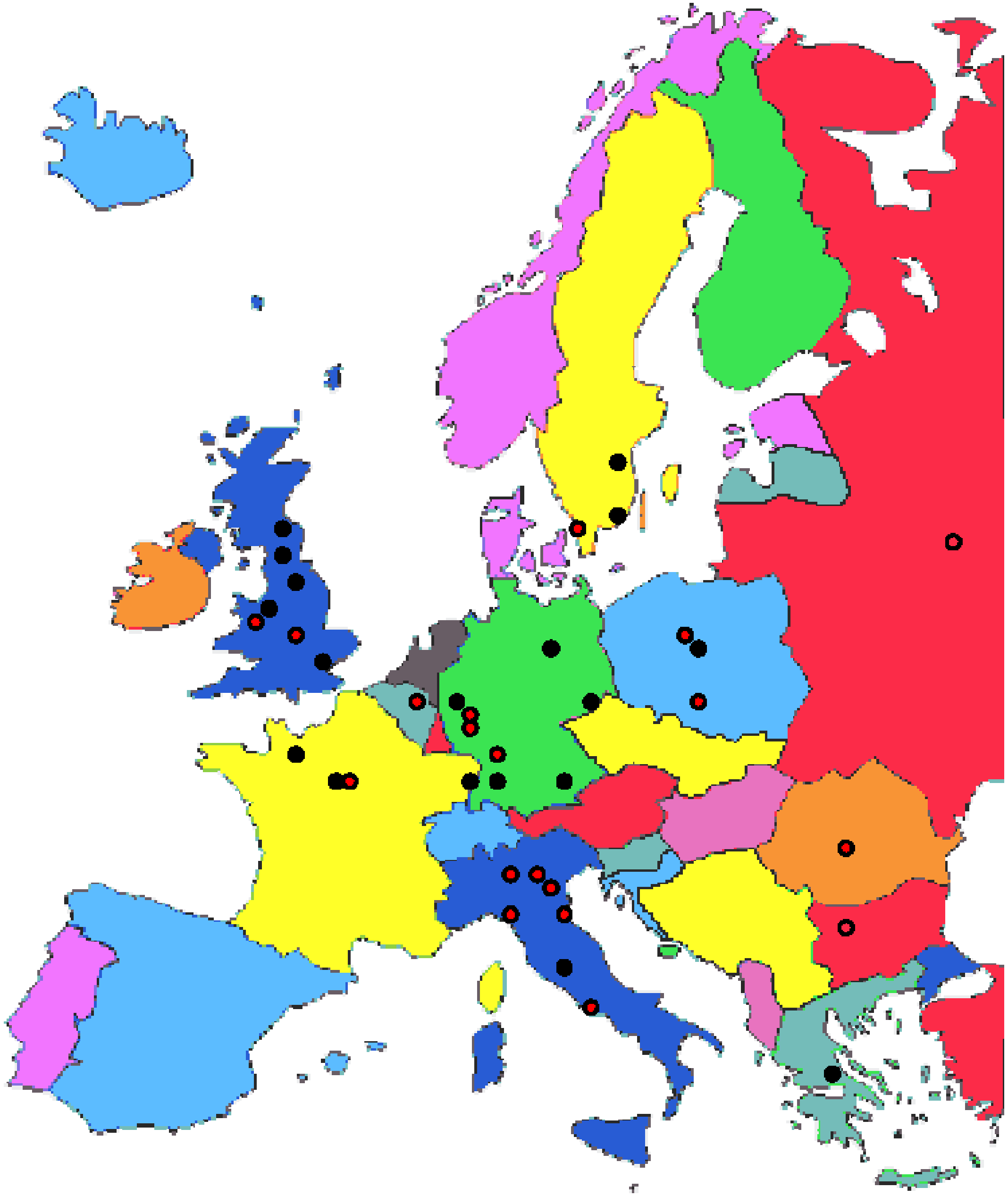
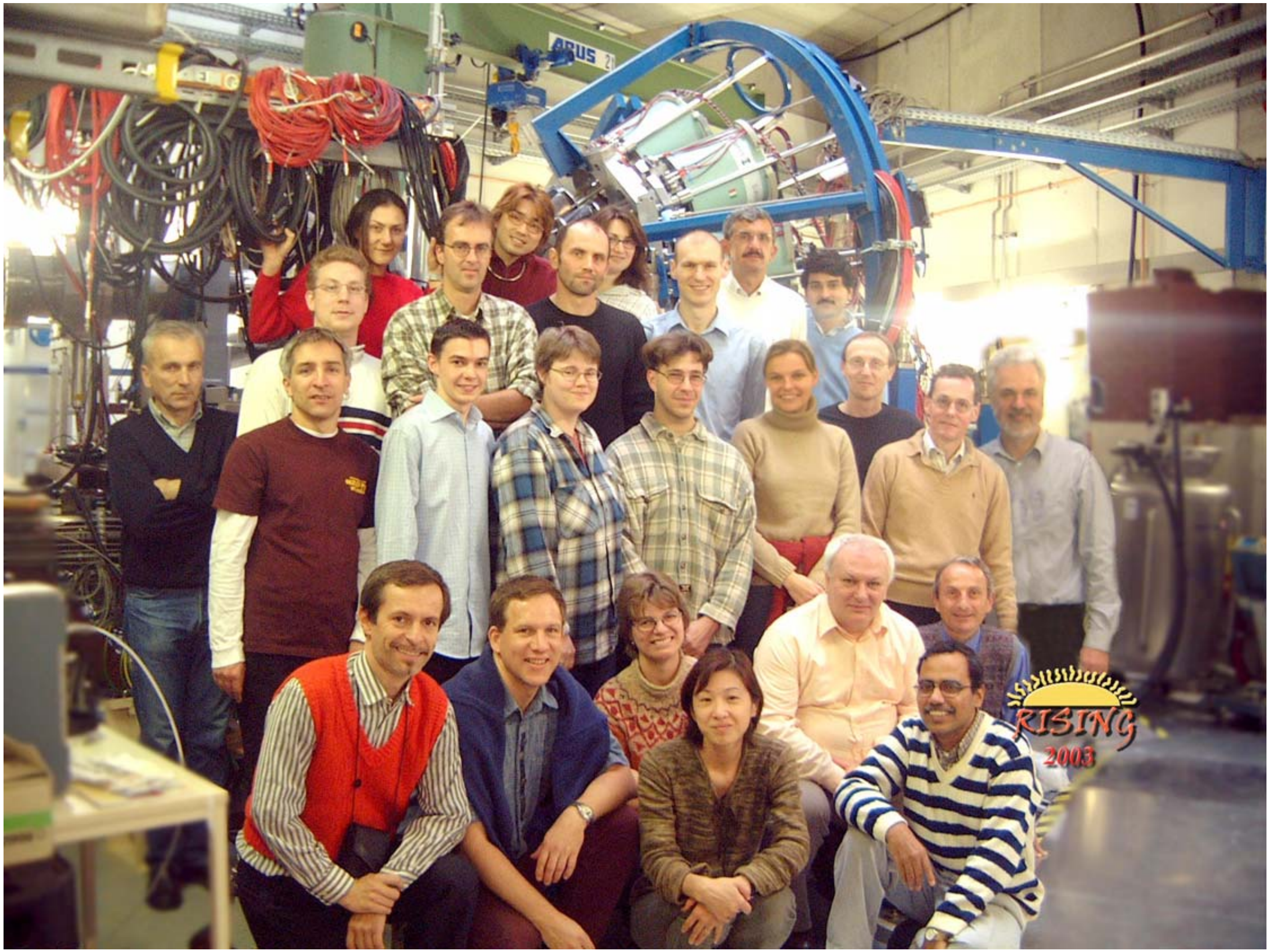


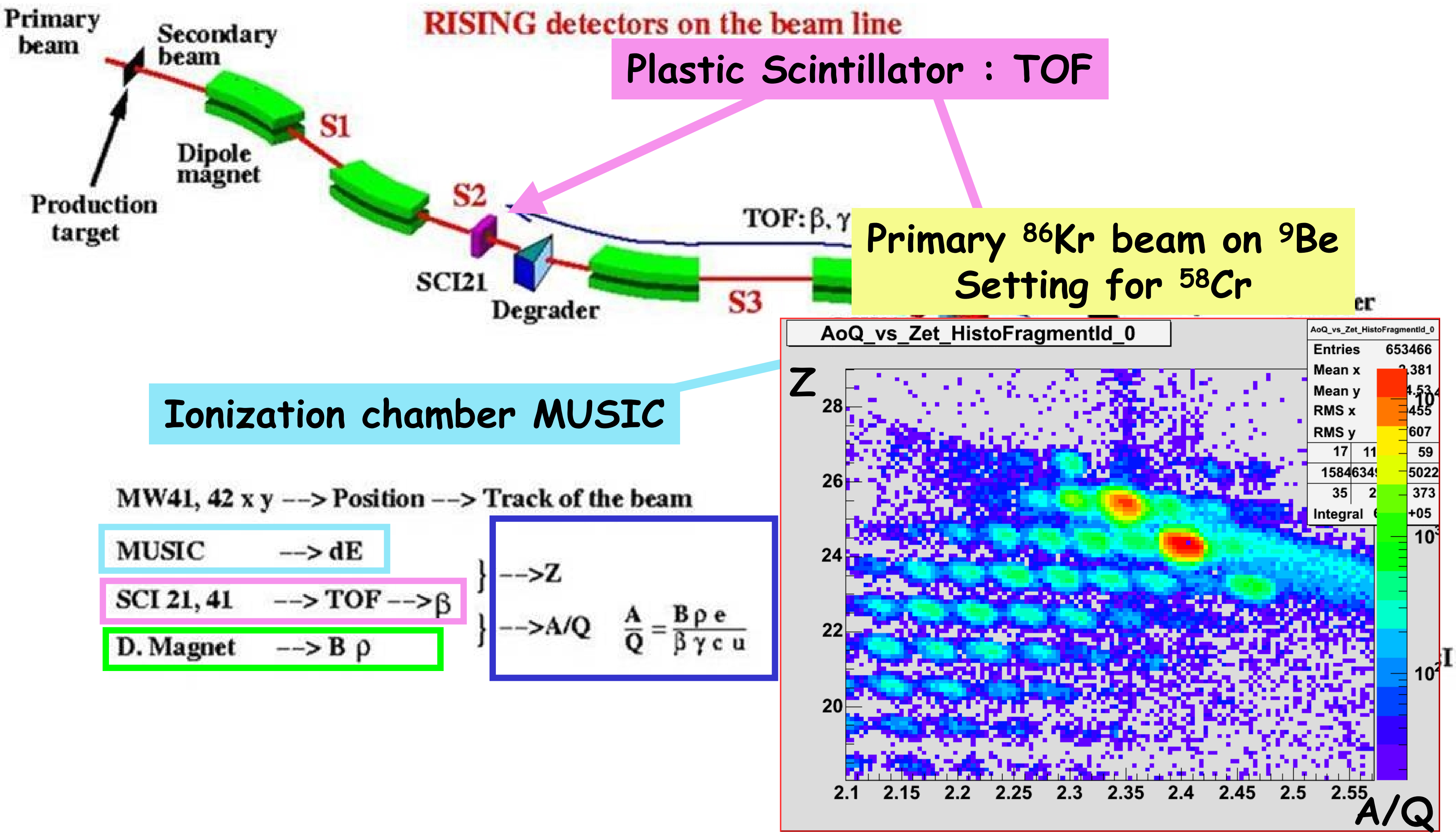


9 countries
38 institutions

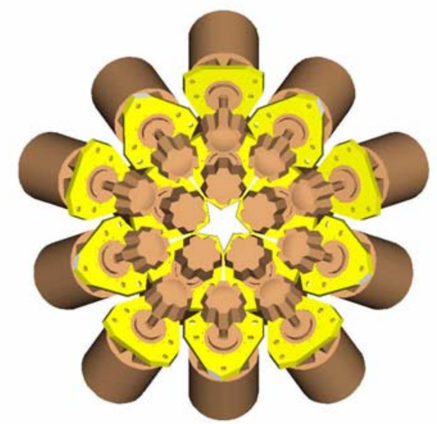
The local RISING team

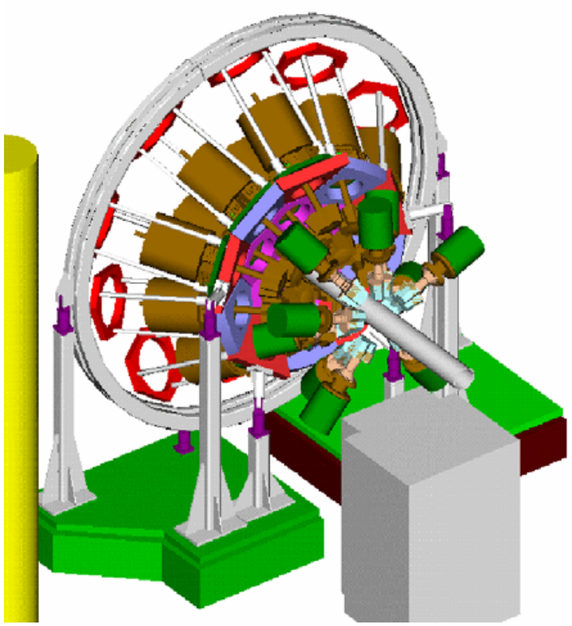


RISING at relativistic energies : FRS



RISING at relativistic energies : Ge detector array





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  - 7 crystals each.
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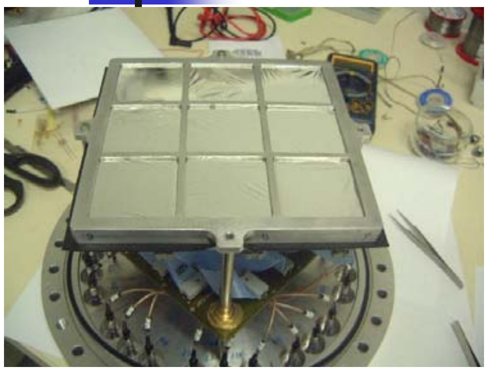
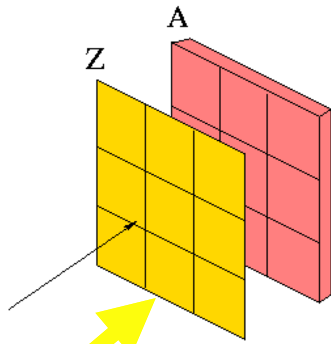
- 8 MINIBALL detectors (end of 2004).
- Wall-like array at forward angle.
  - Large Lorentz boost (β~0.4).
  - Optimum Doppler shift correction.
  - Minimizing Doppler broadening.

- Energy resolution at β~0.4.
  - ~ 1.7% FWHM.

- Photopeak efficiency at β~0.4.
  - ~3% without MINIBALL.
  - 4~10% with MINIBALL.

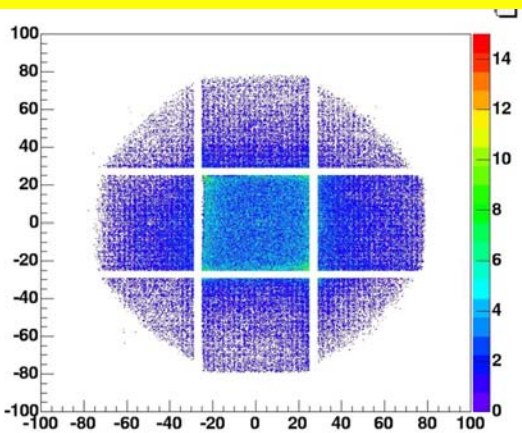
RISING at relativistic energies : CATE (CAlorimeter Telescope Array)



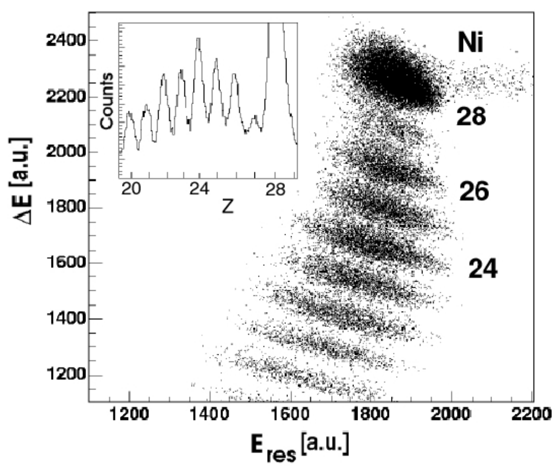


E
- CsI detectors.
- For mass identification.
- Mass resolution : ~1%.

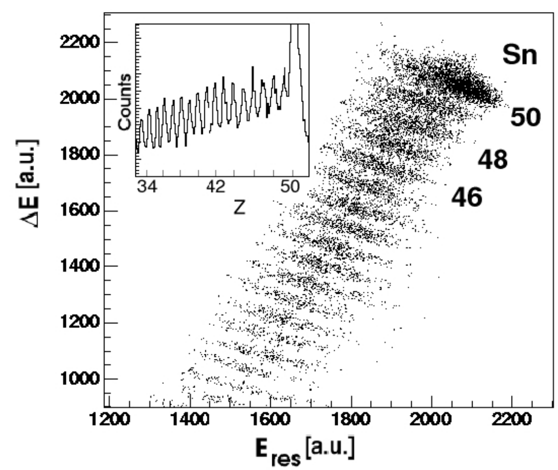
ΔE
- 0.3 mm thick Si detectors.
- For Z identification.
- Position sensitive. Position resolution ~5 mm.



^{55}Ni on ^{9}Be



^{108}Sn on ^{197}Au



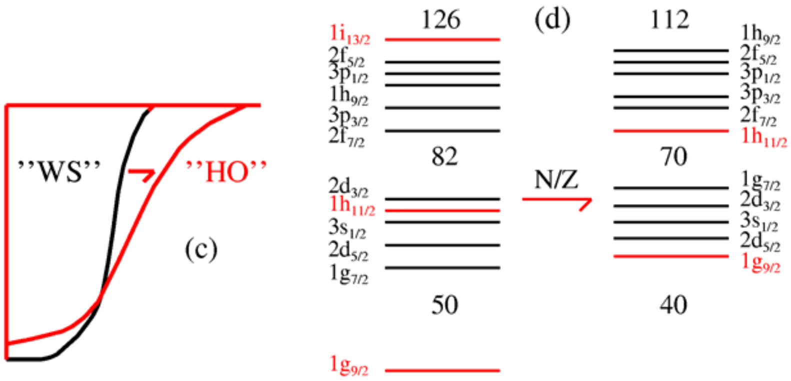
R. Lozeva, Ph.D. thesis

9 countries, 38 institutions.

Institutions collaborating in RISING

GANIL, Caen, France CSNCM Orsay, France IPN Orsay, France CEA Saclay, France	Univ. Demokritos, Greece
CLRC Daresbury, UK Univ. Keele, UK Univ. Liverpool, UK Univ. Manchester, UK Univ. Paisley, UK Univ. Surrey, UK Univ. York, UK	Univ. Firenze, Italy INFN Genova, Italy INFN Legnaro, Italy INFN/Univ. Napoli, Italy INFN/Univ. Padova, Italy Univ. Milano, Italy Univ. Camerino, Italy
HMI Berlin, Germany Univ. Bonn, Germany GSI Darmstadt, Germany TU Darmstadt, Germany MPI Heidelberg, Germany FZ Juelich, Germany Univ. Koeln, Germany LMU Muenchen, Germany TU Muenchen, Germany FZ Rossendorf, Germany	Univ. Lund, Sweden KTH Stockholm, Sweden Univ. Uppsala, Sweden NBI Copenhagen, Danmark
Univ. Leuven, Belgium	IFJ Cracow, Poland Univ. Cracow, Poland IPJ Swierk, Poland Univ. Warsaw, Poland

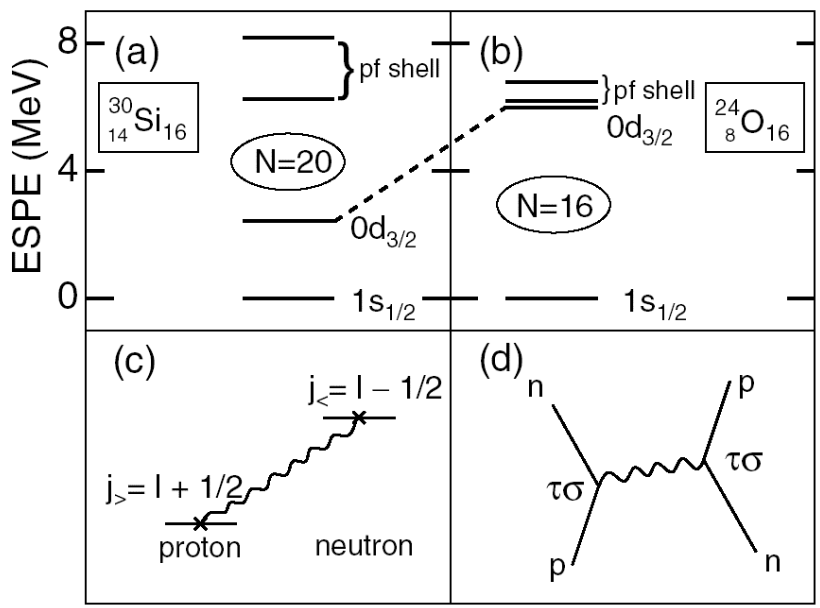
New Shell Structure at N>>Z
Relativistic Coulex in N=28-34, N=40-50 Nuclei



- Neutron excess -> weaker surface slope.
- Reduced spin-orbit LS splitting.

Harmonic oscillator magic numbers.

J. Dobaczewski, et al. PRL 72 (1994) 981



Proton-neutron monopole interaction

- Strongest in S=0 (spin-flip) and T=0 (isospin-flip) channel.
- Missing S=0 proton partners at N>>Z.

Monopole shifts of neutron single particle states

T.Otsuka et al, PRL 87 (2001) 082502

Secondary fragmentation experiment : Mirror symmetry on ^{53}Ni and ^{53}Mn

- **Proposed by M.Bentley et al. Performed in October 2003.**
  - Mirror symmetry on ^{53}Ni and ^{53}Mn.
    - Coulomb energy difference as a function of spins.

-> Talk by M.Bentley. Ph.D. thesis, G.Hammond.